Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

ON THE CHEMICAL COMPOSITION OF AMERICAN SHALES AND ROOFING SLATES.

In the preceding paper the statement is made that the analyses of the green slates at Slatington, Calif., "differ widely from those of any normal clay slates." So little attention is paid to the composition of sedimentary rocks, as compared with that of igneous rocks, that the truth of this statement may not be obvious to all readers. The present paper has been prepared partly for this reason, but more largely because a summary of our present knowledge of the subject seems desirable.

Thirty-six analyses of American roofing slates have been compared and used in the preparation of an average. These analyses include all the published records noted by the writer in the course of an examination of the literature, together with several unpublished analyses obtained from the records of the chemical laboratory of the U. S. Geological Survey. The writer's acknowledgments are due to Dr. F. W. Clarke and Dr. W. F. Hillebrand for aid in this work.

Geographical distribution of the slates.—The thirty-six analyses of slate discussed in this paper represent material from eleven states, representing twelve distinct slate-producing districts. While this geographic distribution is fairly representative of the present condition of the slate industry in the United States, it is by no means representative of the available supply of good material; for, of the twelve states from which analyses are on file, ten are states of the Atlantic seaboard, or closely adjacent thereto. Utah and California furnish the remaining analyses. This distribution is due to purely commercial causes, which have prevented the exploitation of equally good material located in other states, but without transportation facilities or markets. To this extent, therefore, the analyses are not as representative of a given type of material as one might wish.

Geologic distribution of the slates.—Owing in large part to the geographic distribution of the analyses, the geologic distribution has no very wide range. This is due to the fact that in the Atlantic states, which, as above noted, furnish the bulk of the analyses, the true roofing slates are practically confined to the formations below the Medina. Two exceptional instances are represented in the series of analyses. One is a highly metamorphosed slate of doubtfully Carboniferous age; the other is a rather soft slate of undoubted Upper Devonian age. With the exceptions of these two eastern slates, and of the Jurassic slates of California, the analyses represent merely the Ordovician, Cambrian, and, doubtfully, pre-Cambrian. The table below gives the geologic distribution of the analyses in detail:

Age	Number of Analyses
Jurassic	1
Carboniferous?	1
Devonian	1
Upper Silurian	0
Ordovician	11
Cambrian	16
Pre-Cambrian, Cambrian, or Ordovician	6
	36

TABLE I.

RESULTS OF THIRTY-SIX ANALYSES OF AMERICAN ROOFING SLATES.

	Number of Determinations	Maximum	Average	Minimum
Silica (SiO_2)	33	68.62	60.64	54.05
Alumina (Al_2O_3) + titanic oxide (TiO_2)	32[1]	24.71	18.05	9.77
Ferrous oxide (FeO)	19	6.81	3.66	0.97
Ferric oxide (Fe_2O_3)	19	7.10	2.25	0.52
Total iron oxides ($FeO + Fe_2O_3$)	33	10.66	6.87	2.18
Lime (CaO)	34	5.23	1.54	0.00
Magnesia (MgO)	34	6.43	2.60	0.12
Potash (K_2O)	26	5.54	3.69	0.72
Soda (Na_2O)	26	3.15	1.19	0.20
Total alkalies ($K_2O + Na_2O$)	29	8.68	4.74	1.93
Pyrite (FeS_2)	18	.....	0.38	
Carbon dioxide (CO_2)	16	.....	1.47	
Water of combination	15	.....	3.51	
Moisture, below 110° C	16	.....	0.62	

---

[1] In nineteen of these, titanic oxide was separately determined, though it has here been included with the alumina. The average of these nineteen determinations gave 0.73 per cent. TiO_2.

Average chemical composition of American shales.—In *Bulletin 168*, U. S. Geological Survey, on pp. 16, 17, Dr. Clarke has quoted a series of composite analyses of American sedimentary rocks. The material was selected and the samples were prepared by Mr. G. K. Gilbert, assisted by Mr. G. W. Stose, and the analyses were made by Dr. H. N. Stokes in the chemical laboratory of the Survey.

These composite analyses, so far as they relate to shales, are reprinted here as Table II. The determinations of a number of minor constituents are omitted. In this series each individual shale was taken in amount roughly proportional to the mass of the formation which it represented. The samples were then mixed into one uniform sample from which, by a single analysis, an average composition was determined.

In column 1 is given the result of an analysis of twenty-seven Mesozoic and Cenozoic shales; and in column 2 that of fifty-one Paleozoic shales. Column 3 gives the average of these two determinations, giving them, respectively, weights as 3 to 5. The values in this column are, therefore, an approach to the "average shale" composition.

TABLE II.

COMPOSITE ANALYSES OF AMERICAN SHALES.

	1	2	3
Silica (SiO_2)	55.43	60.15	58.38
Alumina (Al_2O_3)	13.84	16.45	15.47
Titanic oxide (TiO_2)	0.46	0.76	0.65
Ferrous oxide (FeO)	1.74	2.90	2.46
Ferric oxide (Fe_2O_3)	4.00	4.04	4.03
Lime (CaO)	5.96	1.41	3.12
Magnesia (MgO)	2.67	2.32	2.45
Potash (K_2O)	2.67	3.60	3.25
Soda (Na_2O)	1.80	1.01	1.31
Carbon dioxide	4.62	1.46	2.64
Water of combination	3.45	3.82	3.68
Moisture, below 110° C	2.11	0.89	1.34

It may be noted in passing that some of the differences in composition between the Paleozoic and the later shales were, either in degree or in kind, contrary to what might have been expected, from a purely theoretical standpoint. The writer is at present inclined to believe that these unexpected results are susceptible of a rational, though decidedly novel, explanation. In case this belief is supported by the results of investigations now in progress, this explanation will be presented in a later paper.

Comparison of "average slate" and "average Paleozoic shale" analyses.—As thirty-five of the thirty-six slate analyses are of Paleozoic material, the "average slate" will obviously be comparable most directly with the composite analysis of the fifty-one Paleozoic shales. The necessity for restricting the comparison in this manner is accentuated by the fact, above intimated, that the Paleozoic and the later shales are not themselves directly comparable.

The average slate contains 60.64 per cent. of silica, as against 60.15 in the Paleozoic shale. Alumina and titanic oxide together amount to 18.05 per cent. in the slate, and to 17.21 per cent. in the shale, the titanic oxide being practically the same in both.

While the proportions of ferrous and ferric iron oxide in the slate and shale are reversed, the *total* amount of iron oxides is very close, being 6.87 in the slate and 6.94 in the shale. The lime and magnesia show the first interesting difference, and this is but slight. While their ratios are closely alike in the two rocks ($\frac{MgO}{CaO} = 1.688$ in the slate, and 1.646 in the shale), the total lime and magnesia in the slate is 4.14 per cent., and in the shale 3.73 per cent. A somewhat similar case occurs with the alkalies. Here $\frac{K_2O}{Na_2O} = 3.101$ in the slate, and 3.564 in the shale; while the total alkalies amount to 4.74 and 4.61 per cent. respectively.

The variations in carbon dioxide, water of combination, and moisture are so slight that they would not appreciably affect the percentages of the other constituents, with the exception of silica and alumina.

Summary of results.—The results of the comparison are mainly negative, but they are of value even in that way.

The average slate is practically identical in composition with the average shale. It contains *slightly* more of certain readily soluble constituents than does the average shale. This is to be accounted for by the fact that the slate is, on the whole, made up from finer materials than the shale; if it were otherwise, its cleavage would not be so perfect. During the change from shale to slate—or from mud to slate—its composition, omitting water from consideration, was practically unaltered. The only effect of metamorphism was the assumption of slaty cleavage, and this was effected without the introduction of any new constituent.

Incidentally, the statement in the preceding paper, that the green slate from Slatington, Calif., differs in composition from any normal clay slate, is entirely justified.

EDWIN C. ECKEL.

U. S. GEOLOGICAL SURVEY,
Washington, D. C.